THE IMMEDIATE EFFECTS OF PRESCRIBED BURNING ON THE VERTEBRATE FAUNA IN A SAGEBRUSH-GRASSLAND ECOSYSTEM ON BURRO HILL, TETON NATIONAL FOREST, WYOMING

John M. McGee

Final Report

THE IMMEDIATE EFFECTS OF PRESCRIBED BURNING ON THE VERTEBRATE FAUNA IN A SAGEBRUSH-GRASSLAND ECOSYSTEM ON BURRO HILL, TETON NATIONAL FOREST, WYOMING

John M. McGee
Department of Zoology and Physiology
University of Wyoming
Laramie, Wyoming 82071

Cooperative Agreement No. 16-376-CA

between

The United States Department of Agriculture
Forest Service

and

The University of Wyoming

January 1976

PREFACE

This document is the final report of the twice amended original contract. The report presents and analyzes research results obtained on the short-term (one year) changes in the numbers and distribution of bird and mammal wildlife species resulting from two controlled burns in a sagebrush-grassland ecosystem in northwestern Wyoming. I am conducting research now on the effects of the burns on the vegetation, and quantitative data on the responses will be available at a later date.

The report is separated into four major sections: the study area; immediate effects on avifauna; immediate effects on mammals; and an appendix containing analyses of the different avian and mammalian components.

INTRODUCTION

For the past 70-80 years wildfire has been nearly completely suppressed in northwestern Wyoming. Consequently, ecosystems in this area have grown and developed in the complete absence of fire. Some questions being asked about wildfire suppression include:

1. What are the effects of total fire suppression on plants and wildlife?

2. What effects will resumed wildfire or prescribed burning have on the components of these ecosystems?

My response to these questions is on an ecosystem level, where management decisions are made.

Presently, there is disagreement over the concept of fire suppression, prescribed burns, "let burn" areas, etc. In most cases disagreements occur at the management level (use of prescribed burning, designation of "let burn" areas, etc.). Most biologists, land managers, and resource specialists, agree on the role of fire in natural ecosystems and its place as a major environmental force shaping forest and sagebrush ecosystems in the northern Rocky Mountains. The ecosystem manager deciding on the management policies concerning the use of fire, must have qualitative and quantitative data on the ecological effects of fire on the ecosystem to make wise decisions.

The purpose of this study is to determine the immediate changes in species composition, density, and biomass of birds and mammals following spring and fall burning in a sagebrush-grassland ecosystem. A secondary objective is to obtain baseline data for a follow-up analysis of the effects during the second calendar year

postburn, and establish permanent methods and sites for periodic long-range monitoring of the fuanal and floristic components of the system.

THE STUDY AREA

The study area is on Burro Hill, a sagebrush-grassland watershed in Teton County, Wyoming, within the boundaries of the Buffalo Ranger District, Bridger-Teton National Forest. Burro Hill is on National Forest land in portions of sections 24 and 25, T 45N, R 113W, and portions of sections 19 and 30, T 45N, R 112W (Figure 1).

Burro Hill is bounded on the west, south and east by the Buffalo River, and on the north by irrigated hayfields and a small lake. The elevation ranges from 2097 to 2253 meters. The topography is gentle and dips gradually to the northeast. Burro Hill is composed of Cretaceous sandstone and shale beds which dip gently to the north. The south and west slopes were created by glaciers and streams cutting through the layered sedimentary beds. These slopes are very steep (60%+) and seldom retain snow. A seasonal stream runs through the middle of the area and supports a *Salix* spp. dominated community. Numerous small ponds remain throughout the spring and early summer, but dry-up by mid-July. The climate of the area is cool and moist, with snow depth of approximately 1 m common on the study area prior to burning. The snow-free period is usually from May to November.

In the past, Burro Hill has been grazed by approximately 270 cattle from the Lava Creek C & H allotment during the first part of the grazing season (the season runs 6/15 to 10/15). Grazing was rotated, but deferred during the season prior to the burns (1974) and the first calendar year postburn (1975). The study area is also utilized by outfitters for big game hunting during the fall.

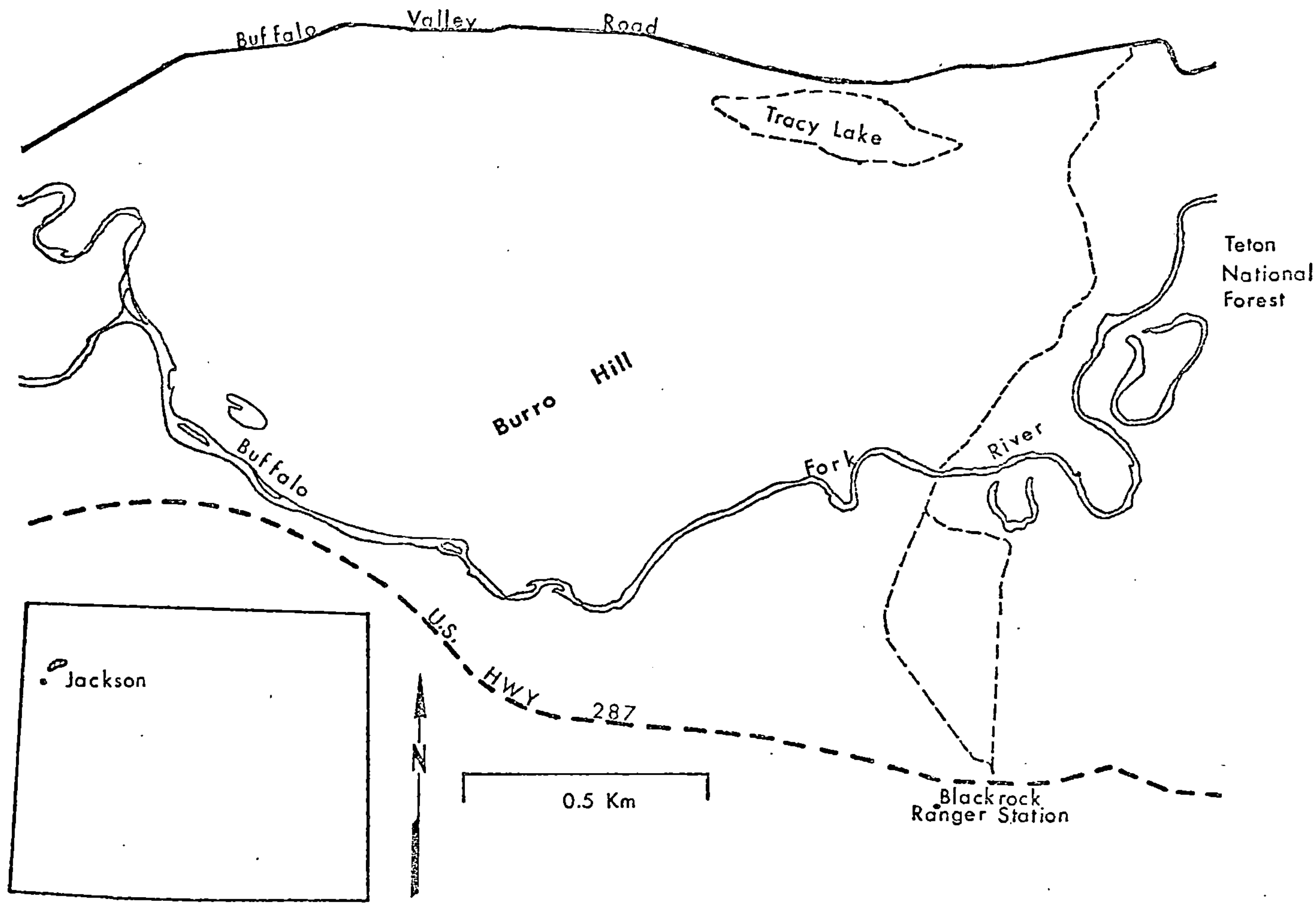

FIGURE 1. Burro Hill study area on the Teton National Forest in northwestern Wyoming.

Aspen (*Populus tremuloides*) patches are present on the moist areas, primarily on northern aspects. These are primarily decadent stands with little or no regeneration and with conifers slowly invading. Conifers dominate the northern and western edges of Burro Hill, areas which have escaped fire in the past, and scattered individuals are located throughout the study area and the *Salix* community.

Due to improved fire detection and suppression techniques, it is estimated that the majority of the hill has escaped fire for at least 75-80 years. A small area of undetermined acreaged, excluded in this study, did burn at the eastern end of Burro Hill in the recent past.

The burn areas were in the large sagebrush-grassland portion of Burro Hill where Mountain Big Sagebrush (*Artemisia tridentata vasyana*) dominated, along with six other less dominant shrubs. The understory of forbs and grasses included sticky geranium (*Geranium viscosissimum*), silky lupine (*Lupinus sericeus*), bluegrass (*Poa* spp.), needlegrass (*Stipa* sp.), and fescue (*Festuca* sp.). Many other species of forbs and grasses were present throughout the growing season. This ecosystem-type is within the Transition Lifezone as classified by Cary (1917). A detailed investigation of the vegetation and the effects of prescribed burning is being conducted by the author and will be available at a later date.

Spring Burn

U.S. Forest Service personnel burned approximately 10-15 ha on

June 3, 1974. Climatological conditions during the burn are presented in Appendix A. The result was a mosaic of areas completely burned, partially burned, and unburned. The fire carried well in areas where sagebrush had been dense and fuel loads relatively high. The mean percent kill of sagebrush for the entire area treated was 81%. All sampling was within the boundaries of this area and care was taken not to approach the outer edges. In the first growing season postburn (1974) regrowth was vigorous. By the end of the second growing season postburn (1975), vegetation covered nearly all burned areas and was dense, providing excellent cover.

Fall Burn

On August 27, 1974, approximately 175-180 ha were burned. Climatological conditions during the burn are presented in Appendix B. Burning was more complete since the vegetation had been through a growing season and was in a cured state, resulting in a higher fine fuel load. The fire carried well between sagebrush plants, resulting in a fire of much higher intensity than the spring burn. All above-ground vegetation was consumed; vast stretches contained no standing vegetation living or dead. Much of the surface litter and humus was also destroyed. Regrowth during the first season postburn (1975) was slower than the spring burn's response, and many burned areas were still very open at the close of the growing season.

Some aspen stands did not burn completely as the understory was still green and would not burn. However, some clones that were surrounded by dense sagebrush were completely consumed resulting in

virtually a 100% kill of all trees and understory vegetation. Many of the moist areas did not burn, or the fire only burned the edges. The *Salix* dominated community was virtually unaffected by the fire. Both the spring and fall burn areas were systematically searched on the day following the fire for burned and/or dead animals.

Immediate Effects On Avifauna

METHODS

Breeding and non-breeding birds were censused on permanent study plots established in 1974. Plots were located within the boundaries of each designated burn area, and controls were situated in adjacent unburned habitat to eliminate extreme differences in slope, exposure, elevation and past vegetational history. Plot sizes were: spring burn - 10.5 ha (25.9 acres); fall burn - 10.8 ha (26.7 acres); unburned-control - 10.0 ha (24.7 acres). A modification of the Williams (1936) spot-mapping technique was employed, which involved determining the number of birds on a plot. Strip transect (Haapanen 1965) and "territory-flush" (Wiens 1969) techniques were used concurrently to increase efficiency and delineation of territories.

Censuses were conducted on foot and all birds encountered within the plots were noted. Birds flying overhead were not counted, with the exception of swallows and raptors which normally feed or hunt on the wing, and therefore would be utilizing the area. Nesting birds were identified by delineating territories where males were singing, and by observations of birds building nests, incubating or feeding young. The number of individuals of non-breeding birds were recorded during each census period on each study plot.

Breeding birds were censused 6 times in 1974 and 7 times in 1975; non-breeding birds were censused 8 times in 1974, and 12 times in 1975. Breeding bird censuses were carried out in the early morning,

beginning one-half hour after sunrise and ending no later than 1100 hrs. Non-breeding birds were censused concurrently, and during additional evening times (between 1700 and 1830 hrs.) throughout the growing season.

Estimated numbers of breeding and non-breeding birds were calculated for each study plot and converted to pairs per 40.5 ha (100 acres). Estimates of standing crop biomass and consuming biomass followed Salt (1957). Mean weights of birds were obtained from Salt (1957), Bock and Lynch (1970), Redfield (1973), Rickleffs (1968), Walkinshaw (1949), and Poole (1938).

Observations on predation pressure by raptorial birds were based on the frequency of occurrence during all periods in the field, hunting behavior (soaring, stooping, etc.), and prey taken. Avian nomenclature follows American Ornithologists' Union (1957; 1973).

RESULTS AND DISCUSSION

Species Diversity

The simplest characteristic to measure is the number of species making up the avifauna. If we accept the generalization that each species occupies a unique niche, then the number of species indicates avian diversity within each study area. Table 1 presents a list of all bird species observed on or near the study areas. Tables 2 and 3 are summary species comparisons of the burned plots and unburned-control areas. These tables show that each burn area and unburned-control contained a distinct species composition which varied between years.

During the 2 years, 42 species representing 10 orders were observed, with more than half (24) being members of the order Passeriformes. The most important family was the Fringillidae (Sparrows, Grosbeaks, and Finches) contributing 9 species. All breeding birds on all areas during both years, except the fall burn in 1975, are members of 19 other families. The results agree with the general conclusions of Klopfer and MacArthur (1960) that passerines are relatively more abundant in the somewhat unstable temperate environmental conditions.

Species composition in the fall burn study area changed more dramatically than in the other study areas between 1974 and 1975. Of all species observed (breeding and non-breeding) the total number of species increased more than two-fold, from 16 to 33 (Table 1). The number of species in common between the fall burn and unburned-control

TABLE 1. Bird species observed on or near the Burro Hill study areas. 1974-1975.

SPECIES	STATUS[a] Spring Burn 1974	Spring Burn 1975	Fall Burn 1974	Fall Burn 1975	Unburned-control 1974	Unburned-control 1975
Turkey Vulture (Cathartes aura)				R		
Sharp-shinned Hawk (Accipiter striatus)				R		
Red-tailed Hawk (Buteo jamaicensis)	R	R	R	A	R	R
Swainson's Hawk (Buteo swainsoni)				R	R	
Marsh Hawk (Circus cyaneus)				A		
Osprey (Pandion haliatus)			R		R	
Prairie Falcon (Falco mexicanus)				R		
Sparrow Hawk (Falco sparverius)	A	R	R	A	R	R
Blue Grouse (Dendragapus obscurus)	B	B	B	A	B	B
Ruffed Grouse (Bonasa umbellus)		R		R		R
Sandhill Crane (Grus canadensis)	R	R		A		
Common Snipe (Capella gallinago)						R
Mourning Dove (Zenaida macroura)				R		
Great Horned Owl (Bubo virginianus)	R			R		
Common Nighthawk (Chordeiles minor)		R		R		
Calliope Hummingbird (Stellula calliope)						R
Red-shafted Flicker (Colaptes auratus)	A	A	R	A	R	R
Hairy Woodpecker (Dendrocopus villosus)				R		
Willow Flycatcher (Empidonax traillii)				R		
Tree Swallow (Iridoprocne bicolor)	A	A	A	A	A	A
Barn Swallow (Hirundo rustica)	A	A	R	A	A	A
Black-billed Magpie (Pica pica)				R		
Common Raven (Corvus corax)		R		R	R	R
Clark's Nutcracker (Nucifraga columbiana)				R		
American Robin (Turdus migratorius)	A	R	R	A	R	R
Mountain Bluebird (Siala currucoides)	A	A	R	A	R	R
Audubon's Warbler (Dendroica coronata)	A	A	R	A	R	R
Wilson's Warbler (Wilsonia pusilla)		R		R		
Western Meadowlark (Sturnella neglecta)			B		B	
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)				R		
Red-winged Blackbird (Agelaius phoeniceus)		R			R	
Brewer's Blackbird (Euphagus cyanocephalus)	A	A		A	A	A
Western Tanager (Piranga ludoviciana)	R	R		R		R
Lazuli Bunting (Passerina amoena)						R
Pine Siskin (Spinus pinus)			R	R		
Green-tailed Towhee (Chlorura chlorura)	B	B	B	A	B	B
Lark Bunting (Calamospiza melanocorys)		R				
Savannah Sparrow (Passerculus sandwichensis)						R
Western Vesper Sparrow (Pooecetes gramineus)	B	B	B	A	B	B
Oregon Junco (Junco hyemalis)	A	R	R	A	A	A
Chipping Sparrow (Spizella passerina)		R			B	
Mountain White-crowned Sparrow (Zonotrichia leucophrys)	B	B	B	A	B	B
SUMMARY						
Breeding	4	4	5	0	6	4
Rare to occasional	4	13	10	17	9	14
Abundant but not breeding	9	6	1	16	4	4
TOTAL	17	23	16	33	19	22

[a]B = Breeding.
R = Rare to occasional - unexpected or irregular occurrences throughout the summer (less than 5 sightings).
A = Abundant but not breeding - expected occurrences throughout the summer (more than 5 sightings).

TABLE 2. Avifaunal species comparison of burned and unburned plots on Burro Hill. 1974-1975. Percentages are of the total within each catagory.

Category	Number and Percent of Species on:							
	Spring Burn		Fall Burn		Unburned-control		Total Species Observed	
	1974	1975	1974	1975	1974	1975	1974	1975
Breeding	4(67%)	4(100%)	5(83%)	0(0%)	6(100%)	4(100%)	6	4
Non-breeding	13(76%)	19(48%)	11(65%)	33(83%)	13(76%)	18(45%)	17	40
TOTAL	17(74%)	23(52%)	16(70%)	33(75%)	19(83%)	22(50%)	23	44

TABLE 3. Number of avifaunal species in common between all study areas on Burro Hill. 1974-1975. Percentages are of total within each catagory.

Category	Number and Percent of Species in Common Between:						
	Spring Burn-Fall Burn	Spring Burn-Unburned-control		Fall Burn-Unburned-control		Total Species Observed	
	1975	1974	1975	1974	1975	1974	1975
Breeding	0(0%)	4(67%)	4(100%)	5(83%)	0(0%)	6	4
Non-breeding	21(53%)	10(59%)	13(33%)	10(59%)	13(56%)	17	40
TOTAL	21(48%)	14(61%)	17(39%)	15(65%)	13(30%)	23	44

study plots changed little. However, no bird species bred on the fall burn area during the first season postburn (Table 2).

Of all species observed during 1975, 21 species (48%) were common to both the spring burn and the fall burn (Table 3). At this time the spring burn was in its second growing season postburn, while the fall burn area was in its first. The two burn areas had no breeding species in common in 1975, since no breeding occurred on the fall burn area.

From these data, the avifauna on the burned plots appears to have been slightly richer in species than the unburned-control plots. This does not seem unreasonable for the spring burn, as many "islands" or patches of partially burned or unburned sagebrush remained following the fire. This increased heterogeneity or patchiness is known to increase species diversity; in that in addition to attracting those species that nested on the area, it also attracted several species that used the area for purposes other than nesting (feeding, hunting, etc.). When the analysis of the vegetation is complete, I will calculate an index of edge diversity and determine if any patterns or correlations exist between the edge resulting from prescribed burning and species diversity. Many of the species (approximately 33%) that fed on the burned areas were known to be nesting in the habitat surrounding the burn (mountain bluebird, red-shafted flicker, tree swallow, sparrow hawk, etc.).

The increase in total number of different species on the fall burn can be attributed to the increase in species of non-breeding birds (Table 2). Those species that nested on the plot in 1974 were observed

on the area in 1975 in a non-breeding capacity. It is not known whether those individuals that nested on the spring burn and unburned-control plots foraged within their nesting habitat or on the fall burn area. The large amount of area burned may also have influenced the increase.

This emphasizes the importance of non-breeding birds to an ecosystem. In terms of ecosystem energetics, to exclude non-breeding birds from an analysis of an avifauna would be an error. An analysis of the quantitative importance of non-breeding species to diversity and stability within seral stages of sagebrush ecosystems is in progress by the author. A more detailed evaluation of the relationships between avian population parameters and habitat alteration is also under study.

Breeding Bird Populations

An analysis of breeding bird densities on all study plots is included in Appendix C. Breeding bird density decreased markedly on the spring and fall burn study areas in their first seasons postburn (Figure 2). The spring burn density in 1974 (the first growing season postburn) was 61% lower than unburned-control density, and increased by 66% the following season (Figure 2). The unburned-control values (the 1974 values for the fall burn plot can be considered as unburned values since bird surveys were conducted before the area was burned) varied little between the two years. The densities on the unburned areas varied by less than 5% between the two years. After two growing seasons, the spring burn density was 63% of the unburned-control value.

The most severe effect of prescribed burning on breeding birds occurred on the fall burn study area. In the first postburn breeding season, no bird species bred on the area and consequently breeding bird densities were estimated as zero. This is not surprising since the fall burn was quite hot and consumed all the standing vegetation and litter. Consequently, the area was in an early seral stage and no suitable habitat or conditions were available for breeding by any of the bird species on or near Burro Hill. Bird species that bred on the area prior to burning in 1974 were present on the area in 1975, but were catagorized as non-breeding. I often observed individuals of these species fly back to the spring burn and unburned-control upon being flushed. However, I never observed individuals fly from the spring burn and unburned-control plots to the fall burn area after flushing.

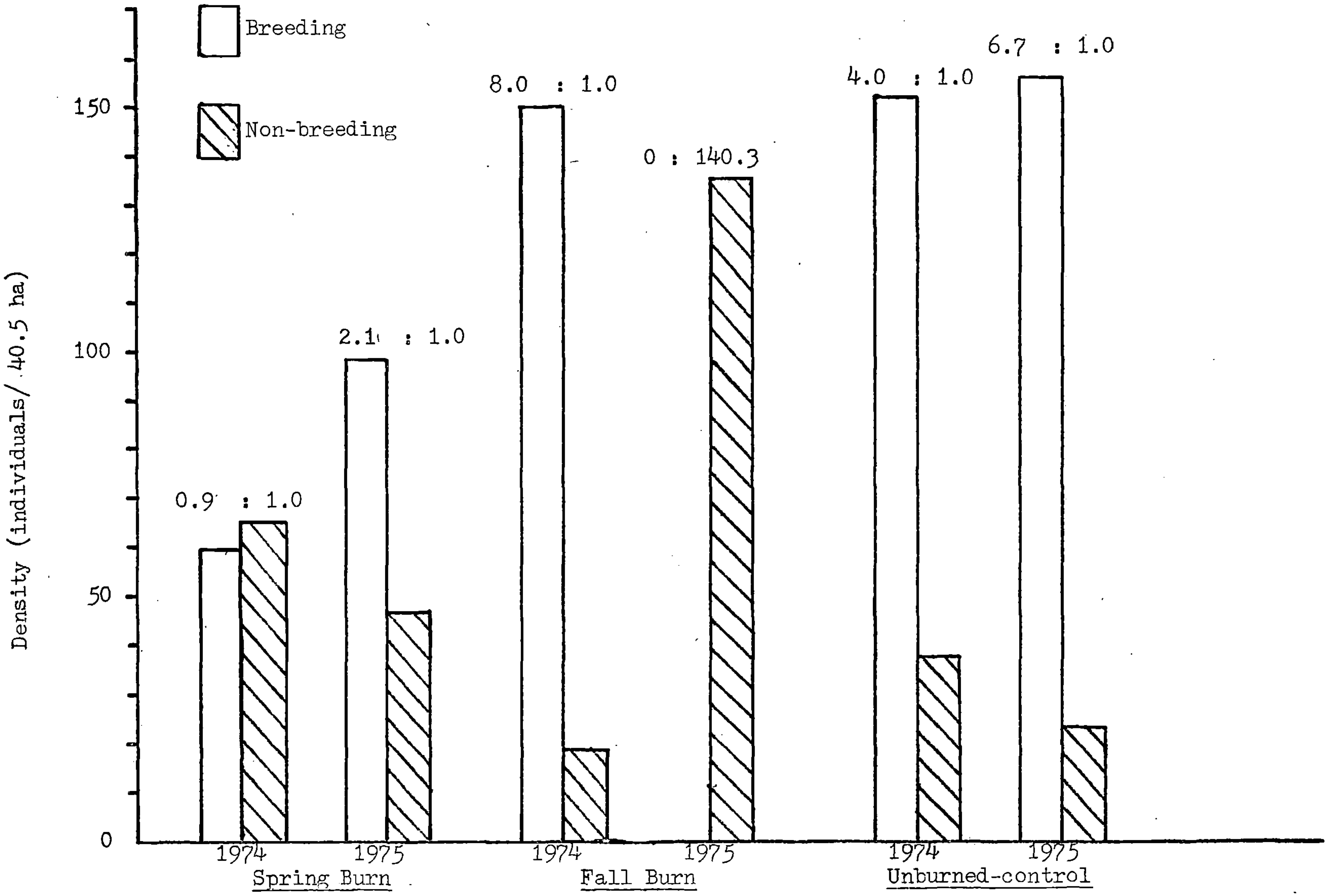

Figure 2. Avian density on Burro Hill prescribed burn study areas. 1974-1975. Figures above bars are ratios of breeding to non-breeding densities.

The decrease in breeding bird densities on the spring burn in 1974 can be attributed to the destruction of suitable nesting habitat. Those species nesting in the spring burn selected nest sites within or under sagebrush plants, or in grass providing good cover. In 1974, 81% of this nesting habitat-type was burned and unavailable, resulting in a decrease in nesting densities; the density of breeding birds was decreased by 61% of the values obtained on unburned-controls. A more detailed evaluation of the response of breeding birds to habitat alteration is currently underway.

In 1975 (the second growing season postburn) the spring burn vegetation grew vigorously, and considerably more grass and forb foliage was available. The breeding birds responded by increasing their densities by 66% over 1974 values. The areas that had been burned supported vigorous stands of vegetation in which the bird species nested readily.

Non-breeding Bird Populations

Most studies on the effects of fire concentrate almost exclusively on the breeding component of the avifauna. In this study I have included an analysis of the non-breeding segment since they undoubtedly play an important role in early secondary succession (Appendices D-F).

In contrast to the breeding birds, the non-breeding birds on the spring burn increased in density relative to the unburned-control values in 1974 (Figure 2); the density of non-breeding birds was 55% higher on the spring burn compared to the unburned-control. In 1975, this density decreased by 28%; however, the density of non-breeding birds on the unburned-control decreased by 38% (Figure 2). The spring burn of 1974 had 81% of the vegetation destroyed, resulting in an open understory. The vegetation responded vigorously during the second growing season postburn (1975) and the previously open areas were covered with dense regrowth, thereby excluding open ground foraging and hunting.

Like the breeding birds, the non-breeding avifauna on the fall burn changed markedly. The density of non-breeding birds increased six-fold from preburn levels during the first season postburn (Figure 2). In all cases, numbers of non-breeding species increased during the first season postburn. In contrast, breeding species on the plot before the burn reappeared on the burned plot as non-breeders, but at lower densities. These increases in non-breeding bird species resulted from the elimination of the previously dense sagebrush-grassland. All non-breeding species were feeding or hunting on the

burned areas, some within minutes after the fire. Non-breeding species prefer the recently burned areas as evidence by the marked increase on the spring burn in 1974 and the fall burn in 1975; simultaneous with a decrease on the other study areas.

The processes of habitat recognition, and habitat selection play important roles in the response of birds to habitat changes. The life form or structural configuration of vegetation often determines what areas birds will select for breeding territories (Lack 1933; Pitelka 1941; Kendeigh 1945; Klopfer 1963). For example, ultimate factors, as well as proximate factors, are believed to be directly involved in the blue-gray gnatcatcher's (Polioptila caerulea) response to a given habitat (Root 1967). Foliage density, which is related to abundance of foliage arthropods, is also an essential part of the nest site selection process. Habitat selection in the case of the gnatcatcher involves two processes: (1) responses which are innate or learned early in life, such as the general region and the spectrum of habitats; (2) assessment of the food supply and perhaps the availability of nest sites, a reaction which takes place when the bird arrives on the breeding ground after its migratory flight. It is likely that the birds on my study areas, both breeding and non-breeding, are utilizing these two processes.

In his work with the birds' response to vegetation changes in a pine plantation, Lack (1933) concluded that the changes in numbers and species were primarily correlated with increasing height of trees. He was the first to show that on successional areas, where revegetation is rapid, avifauna can change drastically in a relatively short time.

The two most important factors were suitable nesting requirements and a correct set of psychological characters. MacArthur, MacArthur and Preer (1962) suggest that numbers and species of birds are correlated with foliage height diversity or patchiness of the habitat. On the Burro Hill study areas, these factors, as well as other vegetative parameters (density, life form, etc.), are undoubtedly affecting the number and species of birds.

Total Avifauna

To determine the effects of the prescribed burns on the total avifauna, breeding and non-breeding values were pooled and analyzed (Appendix G). In 1974, the total density of birds on the spring burn was 34% lower than the density on the unburned-control. This density increased by 16% during the second season postburn, and was only 19% lower than the unburned-control density. The total density on the fall burn area decreased by 20% between 1974 and 1975, 25% lower than the density on the unburned-control in 1975. The unburned-control density decreased 6% from 1974 to 1975.

In 1975, there was a difference of only 10.6 individuals between the spring burn and fall burn study plots. When comparing each treatment plot during its first season postburn, the total avifauna differed by only 10.7 individuals, the fall burn being slightly higher. In other words, after one season following spring and fall burning, total avian densities on the study plots were similar. After two seasons following spring burning, total density was approaching unburned-control values and was slightly higher than the one season postburn value on the fall burn study plot. Therefore, it is clear that by analyzing only one component of the avifauna (breeding pairs) and reporting those results as the total avifauna, the results may be misleading and erroneous with respect to the true total avifauna.

Sagebrush burning resulted in different responses by the total avifauna as well as the different components. Spring burning resulted in decreased breeding-bird densities during the first and second seasons postburn, and increased non-breeding bird densities;

however, total avian density was decreased. Apparently, the nesting habitat and available food were sufficiently affected to cause a population change. However, this change is short-lived, as certain breeding species (vesper sparrow, blue grouse) were at densities equal to those obtained on unburned-control areas in the second season postburn. Non-breeding bird densities were also approaching control values.

Fall burning resulted in a complete elimination of suitable nesting habitat required by those species that nest on Burro Hill; the total avian density was significantly reduced. Non-breeding birds responded in an opposite trend with a conspicuous increase in density. It is clear that a complete removal of suitable nesting habitat and certain psychological characters causes drastic changes in both components of the avifauna.

A conspicuous alteration took place in the ratio of breeding to non-breeding bird densities (Figure 2). The spring burn reduced this ratio to almost a 1:1 value, while the fall burn resulted in a ratio heavily favoring non-breeding birds. On the spring burn, after two seasons postburn, the ratio was approaching unburned-control values. It remains to be seen if this is the case with the fall burn, which caused a more severe reversal of the ratio in the first season postburn. The non-breeding birds were feeding on the burned areas, and apparently there was a large increase in the amount of food utilized by these species in order to maintain the large populations.

The increases in non-breeding bird densities on these burned

areas is most logically explained by an increased availability of food. It is known that fire in chaparral concentrates the seeds of the shrub and grass vegetation on the soil surface (Lawrence 1966). Sweeney (1956) has shown that seeds are readily available on burned ground, and Lawrence (1966) concluded that increased densities of birds on his experimental plots were directly correlated with resulting concentrations of food. Insect numbers on the soil surface are also known to be high following chaparral fires, and more exposed to bird predation (Lawrence 1966). Food preferences and feeding stratagies of the non-breeding species on my study areas make them ideally suited to exploit these increased resources in opportunistic manners.

This again emphasizes the role of non-breeding birds; not considering them would leave an artificially segregated bird population having no relationship to the real and total avifauna of the ecosystem. This is especially so when an ecosystem is under management and succession is set back or otherwise altered.

Biomass

When considering abundance of organisms within an ecosystem, biomass is a useful measure, when you consider that the birds' biomass, and not its number, is consuming, producing, storing, and exchanging energy. The true dominants are not the most abundant species, but those with the highest biomass (Turcek 1956).

In this study I have converted density values to figures of standing crop biomass, and consuming biomass to evaluate energy flow in the avifauna, and the effect of prescribed burning upon this flow (Figures 3-5). Many authors have indicated and discussed the value of expressing biomass values, rather than the number of pairs, or individuals per unit area (Salt 1957; Taylor 1969; and others). The efficiency index (consuming biomass/standing crop biomass) indicates the efficiency of food use (Appendices C-G). A relatively low index indicates a higher efficiency of food use.

Although the spring burn supported a lower density of breeding birds than the unburned-control in 1974, the standing crop biomass was 1.2 times larger than on the unburned-control area (Appendix C). Furthermore, the efficiency index was lower; thus efficiency was higher on the spring burn area. Non-breeding bird densities were higher, however efficiency was also higher.

In 1975, breeding biomass values were highest on the unburned-control but efficiency values were almost identical to the spring burn, indicating that the increased efficiency of food use among breeding birds on the spring burn was short-lived. However, the total avifauna maintained a higher efficiency index.

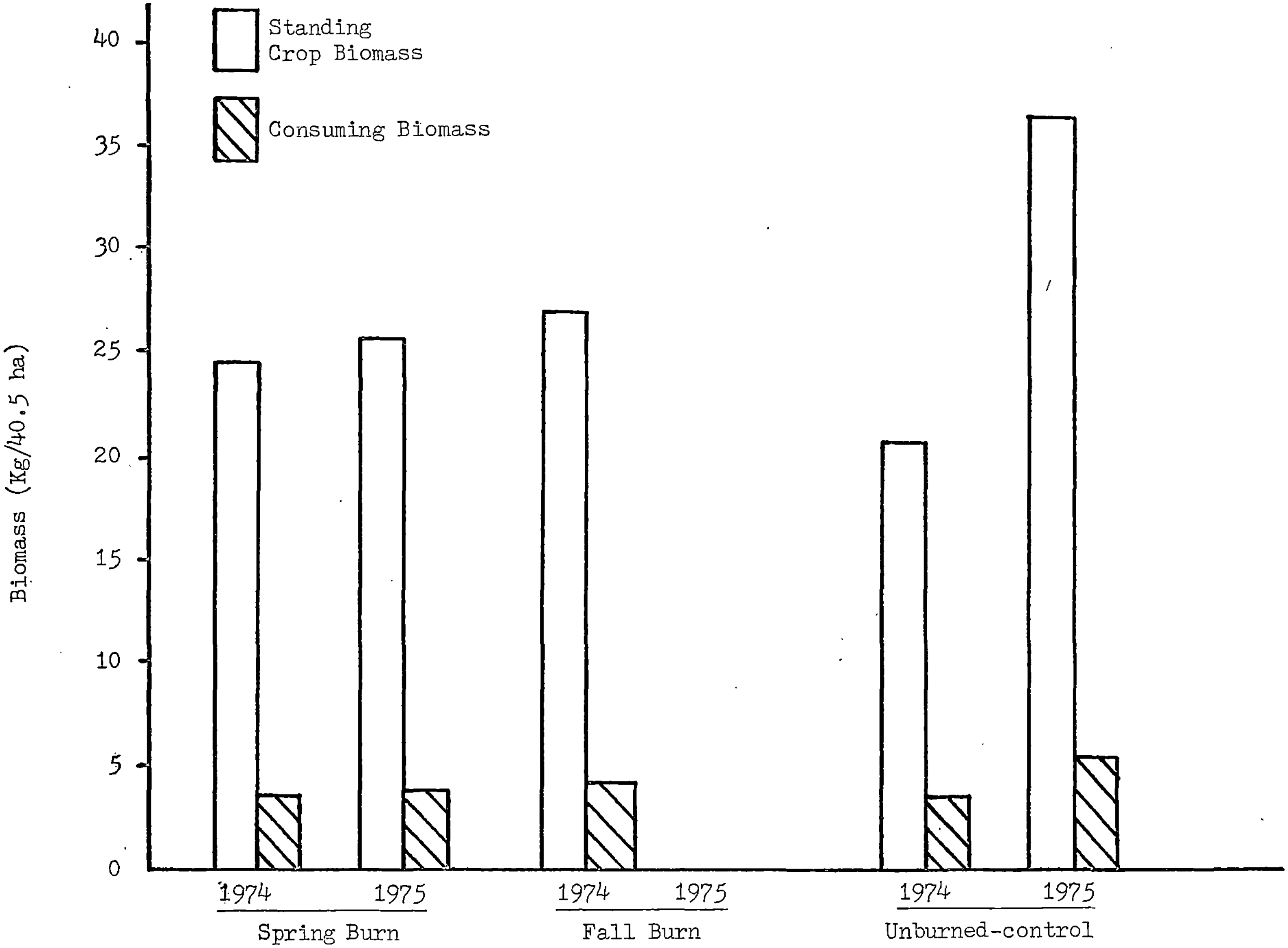

FIGURE 3. Breeding avian biomass on Burro Hill prescribed burn study areas. 1974-1975.

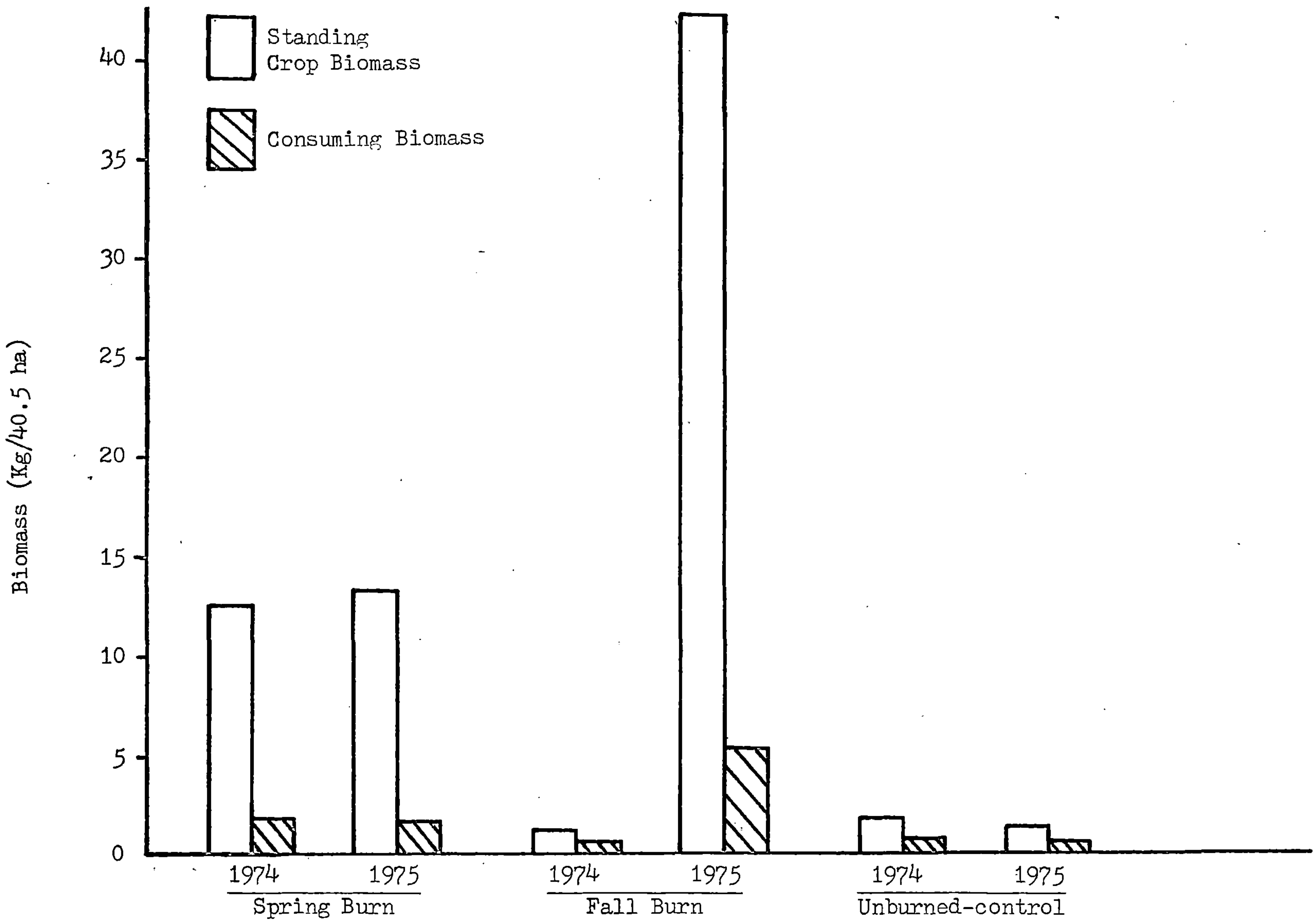

FIGURE 4. Non-breeding avian biomass on Burro Hill prescribed burn study areas. 1974-1975.

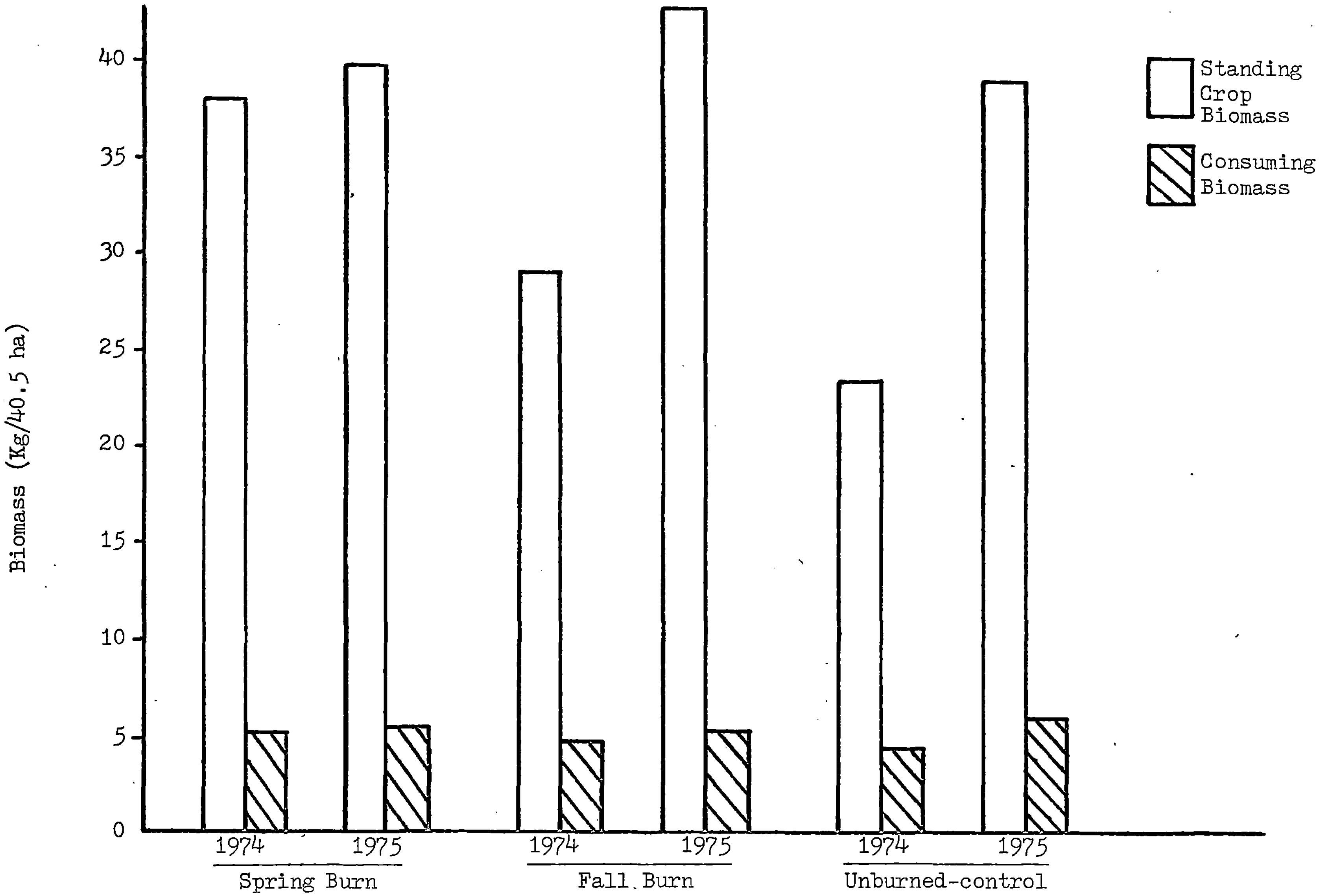

FIGURE 5. Total avian biomass on Burro Hill prescribed burn study areas. 1974-1975.

The fall burn avifauna responded in much the same manner. The trend is caused entirely by the non-breeding segment in which biomass values were markedly higher than unburned-control values, and efficiency was also significantly greater.

The largest increase in biomass values was on the unburned-control area in 1975. This was due to one species, the blue grouse. This may be a temporary effect due to the large area burned in the fall of 1974, which undoubtedly displaced many breeding pairs. If the blue grouse influence is removed, i.e. consider only non-game bird species, the change is very slight (a decrease of 4%).

Salt (1957) pointed out the importance of using biomass values when considering energy flow in a fauna. He considered standing crop biomass to represent the total stored energy present as birds, and consuming biomass as an index of food intake. The ratio of consuming biomass to standing crop biomass is a reflection of the efficiency of a particular species in food utilization; larger birds show a greater discrepancy between consuming and standing crop biomass and a higher efficiency because they require less energy per gram of body weight to sustain themselves (Salt 1957; Bock and Lynch 1970). Consequently, this ratio tends to increase from early to later successional stages, as the percentage of larger species in the population increases. The later successional stage is supporting a larger biomass on a given energy budget; its avifauna can be said to have a greater energy flow through it and greater efficiency in utilizing this energy (Salt 1957).

Salt (1957) also suggested that efficiency in energy metabolism

of an avifauna may be an indicator of metabolism and efficiency of an entire biotic community. He found an increase in efficiency as succession proceeded toward the climax in a coniferous forest.

The efficiency index values for breeding birds and total avifauna on both burn areas in both years were lower than values for the unburned-control areas. This indicates that the avifauna were more efficient on the burned areas, which contradicts the observations of Salt (1957) and Karr (1968); however, my data tend to agree with those of Bock and Lynch (1970). Non-breeding avifauna also followed this trend of lower efficiency indices on the burned areas.

While the burn areas had lower total avian densities than the unburned-control, the standing crop and consuming biomass values indicate that heavier species of birds occurred on the burns than on the unburned-control plots. Mean weight of birds on the burn areas are higher than on the unburned-control areas. Salt (1957) suggested that selection favors large body size because of the advantages gained in food storage. Bock and Lynch (1970) pointed out that body size may prejudice foraging of birds and result in heavier-bodied birds using open habitat created by fire and avoiding mature forest. These two studies base their conclusions on data obtained on breeding bird populations only.

In my study breeding birds responded differently to each type of habitat alteration. The number of different breeding species varied slightly and to draw conclusions based on this component alone would be an error. The species that increased and the new species that utilized the areas after burning are indeed heavier-bodied birds and the vast

open habitat created by burning is ideal for their exploitation of the resources. These species were in the area of the burns prior to burning and utilized the unburned sagebrush-grassland but in relatively lesser amounts. Only following burning did they increase their numbers and utilization of the areas burned.

Predation

In 1974, raptorial birds were observed hunting the spring burn more often than the unburned areas. Three instances of predation were observed when red-tailed hawks took what appeared to be small mammals. Specific identification of the prey could not be confirmed. These predator-prey interactions occurred during the month of June when the open areas were bare and vegetation growth was just beginning. Once the vegetation had begun to accumulate no incidences of predation were noted, although raptors were observed soaring and occasionally stooping throughout the summer. In 1975, during the spring burn's second growing season postburn, raptors were less prevelant; no incidences of prey capture were observed.

The fall burn area incurred relatively high rates of predation by raptorial birds immediately following the burn, and the first growing season postburn. Within minutes after the fire had past, large concentrations of sparrow hawks were observed soaring and hovering over the burned areas. On the following day two pairs of red-tailed hawks and a female marsh hawk were actively hunting the entire burn area. During the summer of 1975, I observed seven instances of predation on small mammals by red-tailed hawks, marsh hawks, and Swainson's hawks. In five cases, Uinta ground squirrels (Spermophilus armatus) were taken by these large hawks; two prey species could not be identified. Raptorial birds were observed to be hunting, soaring, etc. on the fall burn area almost every day I was in the field during the summer of 1975. Hunting pressure was constantly high throughout the summer. The species which exerted the highest predation pressure were

the red-tailed hawk, marsh hawk, and Swainson's hawk; other raptorial species were observed in lesser degrees, although it is assumed they may have taken prey at some time. It is also safe to assume that these avian predators were attracted by the increase in small passerine birds which were in turn attracted to the burns; and that some may have been taken as prey.

Undoubtedly, the removal of the dense sagebrush increased the availability of prey to the hawks; the surviving and immigrating prey species were forced to forage in undesirable places lacking adequate escape cover. Compounding this was an increase in the density of certain prey species, which will be discussed later. *Peromyscus maniculatus* and *Spermophilus armatus* increased on the burn areas in the first season postburn. Concurrent with a vigorous regrowth of vegetation of the spring burn during its second season postburn, was a decrease in numbers of predatory birds; undoubtedly due to an increase in cover.

Immediate Effects on Mammals

METHODS AND MATERIALS

Small Mammals

Trapping Effort

Small mammals were inventoried on 5 live-trapping grids and 5 snap-trapping removal transects. In 1974, Sherman live-traps were arranged in a 5 x 10 grid with 10 meter spacing on the spring burn, fall burn, and unburned-control study areas. In 1975, one larger live-trapping grid was established on the fall burn study area, and one on the unburned-control area for obtaining more detailed information on the larger Uinta ground squirrels, *Spermophilus armatus*. Mammaliam nomenclature follows Long (1965) and Negus and Findley (1959). No. 206 Tomahawk, No. 2 Havahart, and National live-traps were arranged in a 6 x 7 grid with 20 meter spacing. Animals were trapped for 5 consecutive days each month during June, July, and August, and traps were checked 2 or 3 times a day. The size of the area sampled (A_t) by each grid included a boundary strip whose width was one-half the distance between trapping stations; therefore, a Sherman grid sampled an area of 0.5 ha while the larger grid sampled an area of 1.7 ha.

Traps were baited with peanut butter, rolled oats, and bacon grease and replenished when needed. Each trap contained enough bait, and Dacron batting for use as a nest during confinement. All traps were located within 2 meters of the grid intersection, and

special efforts were made to place traps in the shadow of shrubs to reduce mortality due to heat stress. After burning and during early stages of succession, plant cover was nonexistent in certain areas, therefore, traps were checked more often during periods of environmental stress. All mice were individually identified by toe amputation. Ground squirrels were tagged with National Band and Tag Co. Series #1 fingerling tags. Sex, age class, reproductive status, pelage, general condition, and location of capture (grid station) were recorded for all captured animals. Upon capture, during all trapping sessions, each animal was weighed to the nearest 0.1 g with a Pesola spring-balanced Dynamometer, and released at the site of capture.

Removal transects were established in 1975 according to Calhoun and Casby (1958). Two parallel transect lines were established in the fall burn area, and unburned-control area, and one line in the spring burn area. Two Museum Special snap-traps and one Victor rat-trap were placed at each of 20 stations with 20 meter spacing between stations. Traps were checked twice daily for 3 consecutive days each month, and captured animals returned to the laboratory as soon as possible, and frozen for later analysis.

Population and Biomass Estimates

The total number of individuals in the live-trapping areas was estimated by modifiation of the Lincoln Index (Bailey 1952):

$$\hat{N}_T = \frac{m\ (c + 1)}{(r + 1)} .$$

$\hat{N}_T$ is the estimated total number of individuals; m is the number of different individuals captured in the first 4 nights of the trapping period; c is the number captured on the 5th night, and r is the number of different individuals captured on the 5th night that had been captured at least once during the previous 4 nights. This estimate of total number in the trapping area does not include the young that had not been weaned, since these individuals rarely leave their home burrows and consequently are not trappable. Where the total captures was not sufficient to calculate an estimate using this method, the number of different individuals captured during the session was used as a minimum number present. In cases where an individual was not captured in a given session, but was trapped in preceeding and succeeding sessions, I considered the animal to have been present in the area during the intermediate session.

Body weights obtained from captured individuals were used to determine standing crop biomass for the total small mammalian fauna. The average body weight of all species ($\overline{W_T}$) during each period was used to calculate biomass in grams per ha ($\hat{B}_T$) at each time period:

$$\hat{B}_T = \frac{(\hat{N}_T/A_t)}{10,000}\ (\overline{W_T}) .$$

Medium-sized and Large Mammals

Coyotes, *Canis latrans*, were sighted and badger, *Taxidea taxus* activity observed on Burro Hill during both years. Considering the ecology of these two species, no quantitative trapping data were collected, and conclusions are made from visual sightings and observations of individuals and their activities.

Pellet transects were established in 1974 to evaluate big game occurrence and use on burned and unburned study areas: one line on the spring burn; two parallel lines on the fall burn area; and one U-shaped transect and one line-transect on the unburned-control. On each transect, 125 circular plots (0.004 ha) were randomly located, therefore, 0.5, 1.0, and 1.0 ha were sampled on the spring burn, fall burn, and unburned-control areas, respectively. Counts were made in early June and late August of both years. Pellet occurrence was noted and converted to game-days use per hectare using known defecation rates for each species (Neff 1968). Observations on number, sex, and activity were also recorded during all periods in the field.

RESULTS AND DISCUSSION

Small Mammals

Trapping Effort

During the months of June, July, and August, 1974 and 1975, 27 trapping sessions were conducted to evaluate the small mammal populations' response to prescribed burning (Tables 4-6). These sessions represented 12,960 trap nights (product of the number of traps set nightly multiplied by the number of nights operated) of both live and snap-trapping. The average monthly effort was 2,160 trap nights.

A total of 933 captures (508 individuals) were recorded for an overall trapping success of 7%. Trapping success was summarized since trapping effort and frequency were fairly rigid throughout both years. The daily success on various grids ranged from 0 during the early spring to 71% on days late in the summer.

Species Composition and Relative Abundance

Eight species of rodents, 2 species of insectivors, and 1 carnivore were captured during the 2-year period; the deer mouse, *Peromyscus maniculatus*; Uinta ground squirrel, *Spermophilus armatus*; Western jumping mouse, *Zapus princeps*; montane vole, *Microtus montanus*; least chipmunk, *Eutamias minimus*; vagrant shrew, *Sorex vagrans*; long-tailed weasel, *Mustela frenata*; long-tailed vole, *Microtus longicaudus*; cinereous shrew, *Sorex cinereus*; Northern pocket gopher, *Thomomys talpoides*; and red-backed vole, *Clethrionomys*

TABLE 4. Trapping effort, species composition and trapping frequency of small mammals on the spring burn study area, Burro Hill, 1974-1975. Figures in parentheses are the number caught per 100 trap nights.

Trapping Effort and Species	Sherman Live-trap 1974	Sherman Live-trap 1975	Snap trap 1975	Totals
Number of Sessions	3	3	3	9
Trap-nights	1500	1500	540	3540
Open traps	1418	1395	484	3297
Sprung traps	55	30	22	107
Captures	27(1.8)	75(5.0)	34(6.3)	136(3.8)
Percent trapping success	2	5	6	4.3
Peromyscus maniculatus				
Total Captures	9(0.6)	58(3.9)	20(3.7)	87(2.5)
Number of Individuals	2	24	20	46
Spermophilus armatus				
Total Captures	12(0.8)	7(0.5)	2(0.4)	21(0.6)
Number of Individuals	2	3	2	7
Zapus princeps				
Total Captures	1(0.1)	4(0.3)	12(2.2)	17(0.5)
Number of Individuals	1	3	12	16
Eutamias minimus	4	2	0	6
Mustela frenata	1	2	0	3
Sorex vagrans	0	1	0	1
Thomomys talpoides	0	1	0	1

TABLE 5. Trapping effort, species composition and trapping frequency of small mammals on the fall burn study area, Burro Hill, 1974-1975. Figures in parentheses are the number caught per 100 trap nights.

Trapping Effort & Species	Sherman Live-trap 1974	Sherman Live-trap 1975	Ground Squirrel Live-trap 1975	Snap-trap 1975	Totals
Number of Sessions	3	3	3	3	12
Trap-nights	1500	1500	630	1080	4710
Open traps	1377	1171	455	932	3935
Sprung traps	40	45	20	23	128
Captures	83(5.5)	284(18.9)	155(24.6)	125(11.6)	647(13.7)
Percent success	6	19	25	12	16.8
Peromyscus maniculatus					
Total Captures	4(0.3)	284(18.9)	0	113(10.5)	401(8.5)
No. of Individuals	3	100	0	113	216
Spermophilus armatus					
Total Captures	60(4.0)	0	155(24.6)	5(0.5)	220(4.7)
No. of Individuals	6	0	74	5	85
Zapus princeps					
Total Captures	4(0.3)	0	0	7(0.7)	11(0.2)
No. of Individuals	3	0	0	7	10
Microtus montanus	5	0	0	0	5
Eutamias minimus	4	0	0	0	4
Sorex vagrans	2	0	0	0	2
Mustela frenata	1	0	0	0	1
Microtus longicaudus	2	0	0	0	2
Sorex cinereus	1	0	0	0	1

TABLE 6. Trapping effort, species composition and trapping frequency of small mammals on the unburned-control study area, Burro Hill, 1974-1975. Figures in parentheses are the number caught per 100 trap-nights.

Trapping Effort & Species	Sherman Live-trap 1974	Sherman Live-trap 1975	Ground Squirrel Live-trap 1975	Snap-trap 1975	Totals
Number of sessions	3	3	3	3	12
Trap-nights	1500	1500	630	1080	4710
Open traps	1409	1380	601	1031	4422
Sprung Traps	44	46	13	35	138
Captures	47(3.1)	74(4.9)	16(2.5)	14(1.3)	150(3.2)
Percent trapping success	3	5	3	1	3
Peromyscus maniculatus					
Total Captures	6(0.4)	36(2.4)	0	3(0.2)	45(1.0)
No. of Individuals	2	15	0	3	20
Spermophilus armatus					
Total Captures	8(0.5)	0	16(2.5)	6(0.6)	30(0.6)
No. of Individuals	4	0	9	6	19
Zapus princeps					
Total Captures	17(1.1)	24(1.6)	0	5(0.5)	46(1.0)
No. of Individuals	12	17	0	5	34
Microtus montanus	11	0	0	0	11
Sorex vagrans	2	8	0	0	10
Eutamias minimus	2	2	0	0	4
Mustela frenata	1	2	0	0	3
Clethrionomys gapperi	0	1	0	0	1

gapperi. Most captures were of Peromyscus (536), Spermophilus (271), and Zapus (74). These three species comprised 94% of the total captures, where the other 8 species contributed 6% collectively (Table 7).

During 10,260 trap nights of live-trapping, 761 specimens were captured at a rate of 1 animal per 13.5 trap nights or 7.4% success per unit effort; while in 2700 trap nights of snap-trapping, 173 specimens were captured at a rate of 1 animal per 15.6 trap nights or 6.4% success per unit effort. The animals were slightly more prone to capture in live-traps than in snap-traps. Previous studies (Maxell and Brown 1968; Stickel 1946) have indicated that live-traps provided the greatest and most reliable returns. However, due to the varied response of different species to either type of trapping, and since the success per unit effort was similar for both, the results will be considered seperately and conclusions drawn from both sets of data.

Deer mice were captured 536 times (282 individuals) and represented 70% of the total captures on the Sherman live-trap grids, and snap-trap transects, on all areas in both years. Uinta ground squirrels were trapped 271 times (111 individuals) on the ground squirrel grids in 1975, and the Sherman grids on the spring burn in 1974 and 1975. They were selectively excluded from the Sherman grids on the spring burn and unburned-control study areas in 1975. These captures represented 47% of the total captures on the above areas in both years. Western jumping mice were captured 74 times (60 individuals) on all areas in both years, and represented 8% of the total captures. Eight other species were captured at lesser frequencies

TABLE 7. Numbers and frequencies of small mammals in 12,960 trap-nights on Burro Hill prescribed burn study areas. 1974-1975.

Species	Number of Captures	Frequency of Captures
Peromyscus maniculatus	536	0.57
Spermophilus armatus	271	0.29
Zapus princeps	74	0.08
Microtus montanus	16	0.02
Eutamias minimus	14	0.02
Sorex vagrans	13	0.01
Mustela frenata	7	0.01
Microtus longicaudus	2	*
Sorex cenereus	1	*
Thomomys talpoides	1	*
Clethrionomys gapperi	1	*
TOTAL	933	1.00

*Less than 0.01

during the 2 years.

A major result of this study was a significant change in species importance to the total fauna. In the first growing season postburn, deer mice and Uinta ground squirrels collectively, accounted for 78% and 99% of all captures on the spring and fall burn plots, respectively. On the spring burn, by the end of the second growing season postburn, they still accounted for 80% of the total captures. The importance of these two species combined, varied little on the unburned-control plots during 1974 and 1975; 30% and 24% of all captures, respectively.

Spring Burn

Individual species' response to spring burning are summarized in Table 4. Unburned-control results are presented in Table 6. Numbers of the three most abundant species on the burn changed little in 1974 (first growing season postburn) compared to unburned-control values, except the Western jumping mouse. Additionally, no montane voles or vagrant shrews were captured on the burn plot, where 11 and 2 specimens, respectively, were trapped on the unburned-control plot. Four individual least chipmunks were captured, however, none were recaptured. The single long-tailed weasel captured was a mature male and, although never recaptured, was observed on the area at two different times throughout the summer.

Total small mammal density and biomass on the burn in 1974 were lower than unburned-control values during all summer months (Figures 6 and 7). The lower values can be attributed to low numbers of Western jumping mice, Uinta ground squirrels, and montane voles. Total capture rates (number caught/100 trap nights) were also lower on the burned area, supporting the conclusion that densities are lower during the first season postburn relative to unburned-control values. Total small mammal biomass remained relatively constant at low values throughout the summer.

In 1975, the second growing season postburn, total population density was higher on the burn plot than in 1974, however, only in June were numbers higher than unburned-control estimates (Figure 6). Snap-trap results also reflect this increase. The higher density on the burn area can be attributed to the large increase in numbers of deer

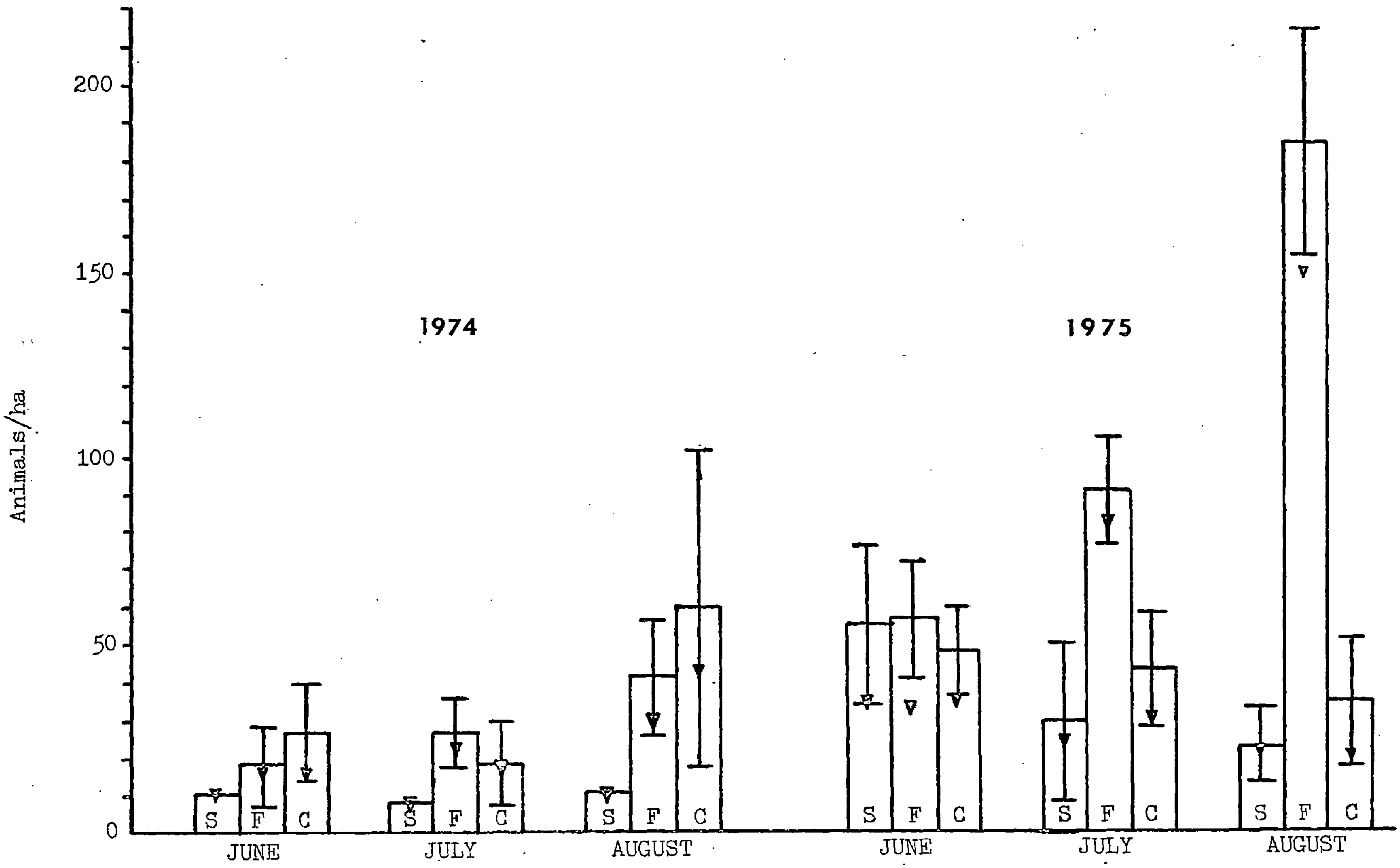

FIGURE 6. Total small mammal density estimates on Burro Hill prescribed burn study areas, 1974 - 1975. Values are based on the minimum number present (▼), and modified Lincoln Index estimates. Vertical lines are the 95 percent confidence limits for Lincoln Index estimates. S = spring burn, F = fall burn, C = unburned-control.

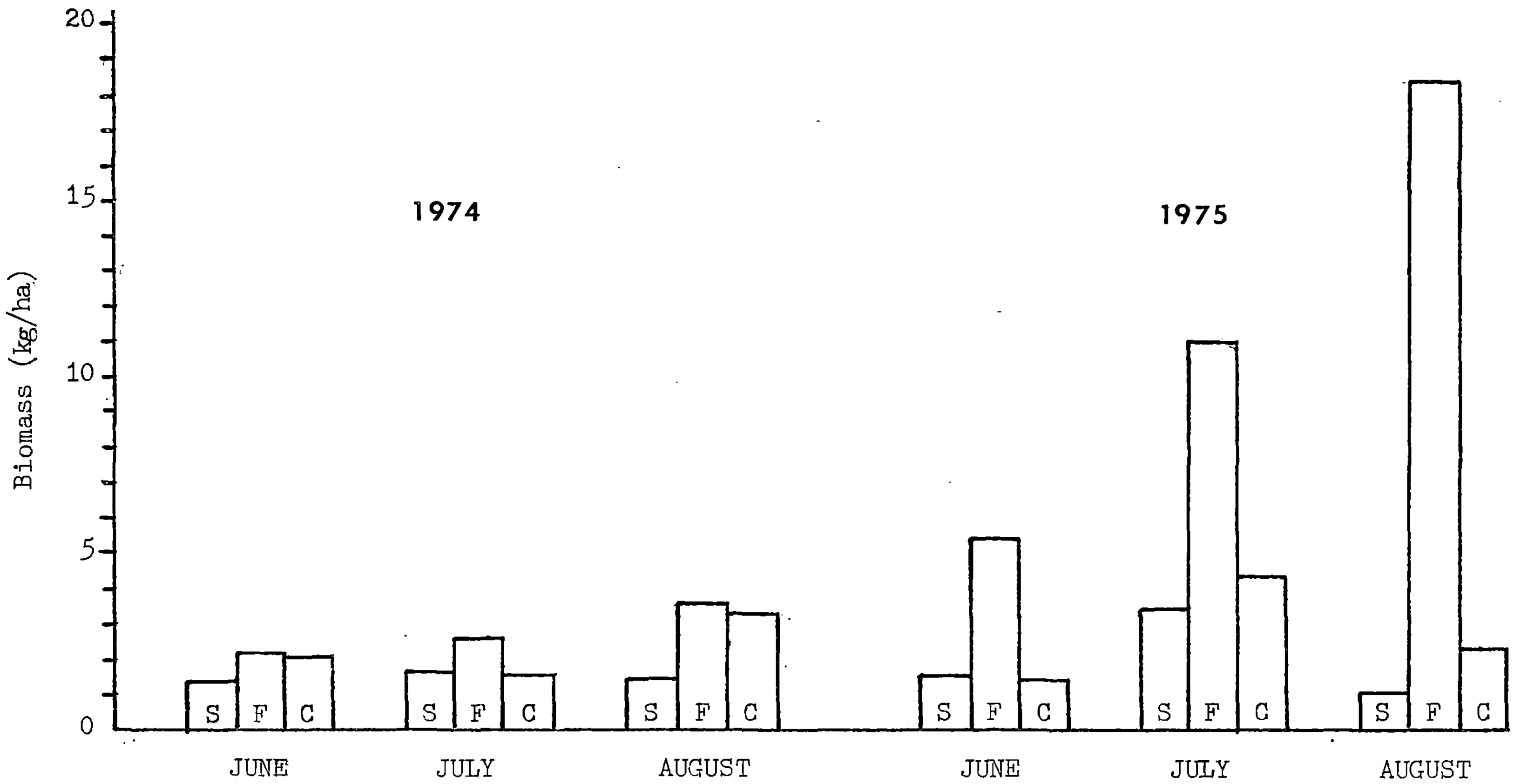

Figure 7. Total small mammal standing crop biomass estimates on Burro Hill prescribed burn study areas, 1974 - 1975. S = spring burn, F = fall burn, C = unburned control.

mice, however, a similar increase occurred on the unburned-control plot although of a lesser magnitude. The trend in biomass changed little between years (Figure 7).

Small mammal population densities decrease to low levels following burning, but this decrease is short-lived. By the end of the second postburn growing season, densities are similar to unburned-control levels, and these responses are caused by one or two species. Biomass changed little during both years, and maintained relatively low levels.

The unburned and partially burned islands that remained following the spring burn undoubtedly served as refuges for small mammals following the fire. These patches were not available on the fall burn area and those species that dominated during the first season postburn were those that nested in burrows in the ground (deer mouse and Uinta ground squirrel). It is also known that microtines with rather specific niche requirements, eg. *Clethrionomys gapperi*, *Microtus montanus*, and *M. richardsoni*, probably cannot sustain populations on burns in the northern Rocky Mountains for 5 to 10 years postburn, perhaps even longer. Cook (1959) discovered that lack of cover following burning is the restricting factor in reducing mouse populations, especially *Microtus*, which require 1 year of mulch for runways. Stout, et al. (1971) correlated the absence of shrews (*Sorex* spp.) on a burn in northern Idaho with their limited powers of dispersal and the lack of ground litter on the burned sites. This may explain the absence of these species on both of my burn areas in the first season postburn, whereas, one

vagrant shrew was captured on the spring burn plot in the second growing season postburn. Stout's data also indicated a significantly reduced species diversity of small mammals in the years following a burn, although his study was conducted in a coniferous forest ecosystem.

Fall Burn

The most dramatic effects of prescribed burning on small mammals were in response to fall burning (Figures 6 and 7). In 1974 the fall burn study plot was not burned until late August, therefore, density and biomass estimates can be considered as unburned values. These estimates varied little from the estimates obtained on the unburned-control plots. In 1975, (the first growing season postburn) only 3 species of small mammals were captured on the fall burn plot and transects, whereas 7 species were trapped on the unburned-control. The 7 Western jumping mice that were trapped on the burn were caught at the two most easterly stations of the snap-trap transects which were nearest to unburned aspen stands. These individuals may represent dispersing or exploring individuals. Only Uinta ground squirrels and deer mice were captured on the live-trapping grids.

Population estimates of Uinta ground squirrels and deer mice increased significantly on the burn area. Increases were also detected on the unburned-control plots but not nearly of the magnitude observed on the burn grid. Snap-trap results also indicated a remarkable increase in deer mice, whereas the capture rate of ground squirrels

decreased. This decrease in ground squirrel capture rates on the snap-trap transects may be an artifact of the sampling method. The stations contained only 1 rat-sized trap, and many deer mice were captured in these traps, thereby decreasing the number of traps available to capture a ground squirrel. No ground squirrels were captured in a Museum Special snap-trap during any session. Since it has been mentioned earlier that live-trapping will provide more reliable results, it is the opinion of the author that ground squirrel populations are better reflected by the results obtained on the live-trapping grids.

P. maniculatus is particularly suited to exploit burns since it prefers seeds of grasses and herbs and insects (Drickamer 1970). Spencer (1955) and Ahlgren (1966) contend that accumulations of seeds remain in unburned portions of forest floors, and production by annual grasses are sufficient to support substantial populations of seed-eating rodents. Microtines, shrews, and various sciurids are dominant in energy transfers among unburned habitats in the northern Rocky Mountains. Many authors (Tevis 1956; Cook 1959; Gashwiler 1959; Lawrence 1966) have shown that granivores are favored in the initial stages of secondary succession following fire. Cook (1959) reported an irruption of Reithrodontomys during a period of maximum seed production. Both Cook (1959) and Lawrence (1966) have documented the shift in Peromyscus species abundance to favor P. maniculatus in the years following burns. I am presently analyzing stomach contents of snap-trapped specimens to determine if the small mammal responses observed in my study are due to changes in diet among the individuals

on the burn areas.

Total small mammal density estimates also increased sharply on the fall burn grid. Density estimates were decidedly higher than the preburn estimates and unburned-control values in 1975. Density increased in a linear fashion throughout the summer of 1975, where unburned-control values decreased, although very slightly. The large increase in total small mammal density is due almost entirely to increases in deer mice and Uinta ground squirrel populations. Total small mammal biomass followed these same trends.

Small Mammal Survival

It is often contended that fire destroys habitat thereby leaving animals helpless and totally vulnerable to exposure, starvation, and predation. The burns conducted in this study although controlled, resulted in a conflagration similar to a wildfire. The fall burn was a severe, hot, and killing fire which opened up the area extensively and should have been sufficient to destroy or depopulate the habitat. Increased predation was observed by red-tailed hawks, marsh hawks, and sparrow hawks on the burned areas during the first growing season's postburn. The primary mammalian predators on small mammals were the long-tailed weasel, coyote, and badger. However, substantial, and in some cases extremely high numbers of small mammals were trapped, casting obvious doubts on the alleged mortality caused by fire. Adjacent control grids and transects reflected no emigration of marked small mammals from any of the experimental burn study areas. The study grids and transects are located

so that edge and treatment effects are not manifested in sampling results from any study area. Further evidence that resident small mammals did survive the fire is based on live-trapping results in June, 1975. Three Uinta ground squirrels marked on the fall burn Sherman grid in 1974 before prescribed burning were captured in peripheral traps on the larger grid established in 1975. Furthermore, since no dead and/or charred animals were found on the burn areas immediately after treatment, the contention that these burns had a negligible mortality effect on small mammals is further supported.

Therefore, moderate and severe prescribed burning altered the composition of the species and produced different population responses by individual species. These changes associated with burning are considered to be directly related to the alteration of the gross physiognomy of the vegetation. The burns not only changed the structure of the community but most likely altered food and microhabitat characteristics. The time of burning, spring or fall, will produce qualitatively and quantitatively different results.

The results of this study indicate that prescirbed burning influenced species diversity (number of species) and density of small mammals within the sagebrush-grassland ecosystem. In addition, the time of burning (spring or fall) produced different effects on the composition and number of individuals of each species. The reduction in species diversity was more pronounced following the fall burn where 6 species that had been present before burning were not trapped during the first growing season postburn. Those species that did survive

increased their numbers significantly, possibly as a response to reduced competition. These results support the contention that total small mammal numbers are not depleted by fire, but that there is a differential effect on the species present before burning. Fire is a variable that is superimposed on varied landscapes with their assorted microdiversities and multitudes of organisms with inherent biological variations and, therefore tends to produce multiple changes (Vogl 1973). Consequently, effects that may be classified as destructive by man may be beneficial to certain organisms.

Medium-sized And Large Mammals

Adult coyotes were seen on the fall burn study area once prior to burning in 1974, and once after burning in 1975. Both individuals were moving away when spotted and their prior activity is unknown. An active den was located in June, 1974, in the aspen community approximately 50 meters from the northern sagebrush-aspen interface. One female and four pups were observed on 14 June and two days later no activity was noted. It appeared as if the bitch had abandoned the den and possibly moved the pups elsewhere. No activity was noted at the den in 1975. In 1975, a large adult was observed running southward over the fall burn area. Based on this evidence, it seems likely that coyotes were present in the sagebrush ecosystem prior to and during the first season after fall burning, but for what specific purpose is unknown. No estimate of density could be made from these data.

Badgers were never observed, however, diggings characteristic of this species were located during both years on all study areas indicating their presence. In the unburned areas activity was sparse and diggings were encountered infrequently. On the spring burn area during 1974 and 1975 evidence of activity was located at the same frequency as on the unburned-control areas. Badger activity, based on the number of holes and diggings, appeared to be greatest on the fall burn area during August, 1975. Fresh holes were being dug at frequent intervals; however, due to the nature of the species it is difficult to determine if more than one individual was in the

area. The holes were located near known ground squirrel burrows, and it is highly likely that the badger is a predator of small mammals, but to what degree is unknown.

Three species of large ungulates were observed on the study areas during both years: American elk (Wapiti), Cervus canadensis; moose, Alces alces; and mule deer, Odocoileus hemionus. These species were observed on both burn areas and unburned-control during both summers. During one winter observation trip in 1974, elk and moose sign was observed on the study areas, but no individuals were sighted. Table 8 presents a summary of the fecal pellet count measurements.

Big game use of the spring burn during 1974 was very light as indicated by the pellet count data and observations. Elk and moose were on the area before it was burned, as the June, 1974, pellet count data indicates some use during the previous winter. No sign was detected on the August survey. Two mule deer, 1 buck and 1 doe, were observed feeding in the area once during the entire summer. In 1975, elk use was higher than in 1974, as pellet frequency increased and individuals were observed more often feeding on the area. Although no moose pellets occurred in plots on the transect surveys, 1 cow was observed feeding on the area in June, 1975.

In 1974, prior to fall burning, elk use was relatively high in the unburned sagebrush. Elk were observed on the area on numerous occasions early in the summer. Herds consisted of cows and calves, where elk were known to have used the surrounding aspen community as calving areas. The most frequently observed activity was feeding, when the animals were first spotted in the early morning. All

TABLE 8. Summary of fecal pellet-counts on Burro Hill prescribed burn study areas, 1974-1975. Values are total number of pellet groups per hectare. Figures in parentheses are frequency of occurrence of pellet groups in plots.

Species	Spring Burn		Fall Burn		Unburned-control	
	June	August	June	August	June	August
1974						
Elk	4(1.6)	0	8(3.2)	8(3.2)	6(2.4)	2(0.8)
Moose	2(0.8)	0	0	0	1(0.4)	1(0.4)
Deer	1(0.4)	0	0	0	0	0
1975						
Elk	10(3.2)	2(0.8)	8(2.8)	1(0.4)	1(0.4)	1(0.4)
Moose	0	0	2(0.8)	0	0	0
Deer	0	0	0	0	1(0.4)	0

individuals took flight into the aspen when I was detected. In 1975, the first growing season postburn, elk were observed less frequently than before burning. Pellet count data indicates use had decreased, and all individuals observed were single cows traversing the area toward surrounding habitat.

Moose were seen most often in the Salix spp. dominated community, and aspen groves surrounding the sagebrush study areas. Most observations were of individuals walking or running across the sagebrush toward other communities.

The limited data on the response of big game to prescribed burning indicate that elk activity was altered most. Due to the small size of the spring burn, it is difficult to ascertain population responses to spring burning. Pellet count data indicate that elk use was higher during the first fall and winter postburn, and that summer use was low during the first and second summers postburn. Visual observations indicated that elk utilized the area more during the second summer postburn, although the total number of observations was low.

Summer use of the fall burn by elk was changed most noticeably. During the first growing season postburn (1975), elk used the area far less than before the fall burning. No feeding was observed by any individual sighted, as all were moving toward cover when seen. Most of the elk and mule deer sighted on the burned areas were along edges near unburned aspen communities which they used for escape cover.

Forest Service personnel have indicated to me that a small number (approximately 20) of elk had wintered in the past within the

conifers and on the western slopes of Burro Hill. The scope of this research does not allow me to draw conclusions regarding the factors affecting fall and winter use of the sagebrush ecosystem by big game. Elk use of Burro Hill prior to burning was limited to calving in the surrounding aspen communities and feeding in the sagebrush during the spring and early summer. This early summer use of the sagebrush community was altered more so by fall burning with limited use during the first growing season postburn.

LITERATURE CITED

Ahlgren, C.E. 1966. Small mammals and reforestation following prescribed burning. J. For. 64:614-618.

American Ornithologists' Union. 1957. Checklist of North American birds. Fifth Edition, Baltimore, 691 pp.

American Ornithologists' Union. 1973. Thirty-second supplement to A.O.U. checklist of North American birds. A.O.U. Committee on classification and nomenclature, The Auk, Vol. 90, No. 4.

Bailey, N.T.J. 1952. Improvements in the interpretation of recapture data. J. Anim. Ecol. 21:120-127.

Bock, C.E. and J.F. Lynch. 1970. Breeding bird populations of burned and unburned conifer forest in the Sierra Nevada. Condor 72:182-189.

Calhoun, J.B. and J.U. Casby. 1958. Calculation of home range and density of small mammals. Public Health Monogr. 55. 24 pp.

Cary, M. 1917. Life-zone investigations in Wyoming. N. Amer. Fauna, 42:1-95.

Cook, S.F. 1959. Effects of fire on a population of small rodents. Ecology 40:102-108.

Drickamer, L.C. 1970. Seed preferences in wild caught Peromyscus maniculatus bairdii and Peromyscus leucopus noveboracensis. J. Mammal. 51:191-194.

Gashwiler, J.S. 1959. Small mammal study in west-central Oregon. J. Mammal. 40:128-139.

Haapanen, A. 1965. Bird fauna of the Finnish Forests in relation to forest succession. I. Annales Zool. Finnici 2:153-196.

Karr, J.R. 1968. Habitat and avian diversity on strip-mined land in east-central Illinois. Condor 70:348-357.

Kendeigh, S.C. 1945. Community selection in birds on the Heidelberg Plateau of New York. Auk 62:418-436.

Klopfer, P.H. and R.H. MacArthur. 1960. Niche size and faunal diversity. Amer. Nat. 94:293-300.

Klopfer, P.H. 1963. Behavioral aspects of habitat selection: the role of early experience. Wilson Bull. 75:15-22.

Lack, D. 1933. Habitat selection in birds with specific reference to the effects of afforestation in the Breckland avifauna. J. Anim. Ecol. 2:239-262.

Lawrence, G.E. 1966. Ecology of vertebrate animals in relation to chaparral fire in the Sierra Nevada foothills. Ecology 47:278-291.

Long, C.H. 1965. The mammals of Wyoming. Univ. Kansas Publ. Vol. 14 (18): 493-758.

MacArthur, R.H., J.W. MacArthur and J. Preer. 1962. On bird species diversity II. Prediction of bird census from habitat measurements. Amer. Nat. 96:167-174.

Maxell, M.H. and L.H. Brown. 1968. Ecological distribution of rodents on the high plains of eastern Wyoming. Southwest. Nat. 13:143-158.

Neff, D.J. 1968. The pellet-group count technique for big game trend, census, and distribution: a review. J. Wildl. Mgmt. 32: 597-614.

Negus, N.C. and J.S. Findley. 1959. Mammals of Jackson Hole, Wyoming. J. Mammal. 40:371-381.

Pitelka, F.A. 1941. Distribution of birds in relation to major biotic communities. Amer. Midl. Nat. 25:113-137.

Poole, E.L. 1938. Weights and wing areas in North American birds. Auk 55:511-517.

Redfield, J.A. 1973. Variations in weights of blue grouse (Dendragapus obscurus). Condor 74:312-321.

Rickleffs, R.E 1968. Patterns of growth in birds. Ibis 110:419-451.

Root, R.B. 1967. The niche exploitation pattern of the blue-gray gnatcatchers. Ecol. Monogr. 37:317-350.

Salt, G.W. 1957. An analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor 59:373-393.

Spencer, D.A. 1955. The effects of rodents on reforestation. Proc. Soc. Amer. For. 1954:125-128.

Stickel L.F. 1946. Experimental analysis of methods for measuring small mammal populations. J. Wildl. Mgmt. 10:150-159.

Stout, J., A.L. Farris and V.L. Wright. 1971. Small mammal populations of an area severely burned in northern Idaho in 1967. Northwest Sci. 45:219-225.

Sweeney, J.R. 1956. Responses of vegetation to fire: a study of the herbaceous vegetation following chaparral fires. Univ. Calif. Publ. Bot. 28:143-250.

Taylor, D.L. 1969. Biotic succession of lodgepole pine forests of fire origin in Yellowstone National Park. Ph.D. thesis. Univ. Wyoming. 320 pp.

Tevis, L. 1956. Responses of small mammal populations to logging of Douglas Fir. J. Mammal 37:189-196.

Turcek, F.J. 1956. On the population of the spruce forest community in Slovakia. Ibis 98:24-33.

Vogl, R.J. 1973. Effects of fire on the plants and animals of a Florida wetland. Amer. Nat. 89:334-347.

Walkinshaw, L.H. 1949. The Sandhill Cranes. Cranbook Inst. Science. Bull. No. 29.

Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. No. 8. 93 p.

Williams, A.B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr. 6:318-408.

APPENDICES

Appendix A. Climatological conditions on Burro Hill during the spring burn, June 3, 1974 (Courtesy of Buffalo Ranger District, U.S. Forest Service).

Burning Index	11
Maximum Temperature	68° F
Minimum Temperature	27° F
Maximum Relative Humidity	99%
Minimum Relative Humidity	30%

Wind was from the west and averaged 6 mph, varing from 6 to 15 mph. Skies were partly cloudy. There was no precipitation for three days prior to the burn, but one good storm was recorded one week before the burn. Fine feul moisture was 8%, one-hour timelag fuel moisture was 7%, and 100-hour timelag fuel moisture was 17%.

Appendix B. Climatological conditions on Burro Hill during the fall burn, August 27, 1974 (Courtesy of Buffalo Ranger District, U.S. Forest Service).

Burning Index	10
Maximum Temperature	82° F
Minimum Temperature	32° F
Maximum Relative Humidity	100%
Minimum Relative Humidity	21%

The day was partly cloudy with some convection-type clouds. Wind was from the west at 4 mph and ranged from 0 to 15 mph. No precipitation was recorded for ten days previous to the burn. The fine fuel moisture was 4%, the 10-hour timelag fuel moisture was 7%, and the 100-hour timelag fuel moisture was 19%.

Weather Pattern for August 27, 1974

0630 hrs	wet bulb 39° dry bulb 41°	no wind, clear skies
0900 hrs	wet bulb 50° dry bulb 61°	wind 0-3 mph from s.e. burning unsuccessful until 1000 hrs.
1300 hrs	relative humidity 23%	
1530 hrs	wet bulb 59° dry bulb 84°	wind out of west 9-10 mph.

Appendix C. Analysis of breeding avifauna on all Burro Hill study areas. 1974-1975.

Species	Density (Pairs /40.5 ha)		Mean wt./ bird(g)	Standing Crop Biomass (g/40.5 ha)		Consuming Biomass (g/40.5 ha)		Efficiency Index	
	1974	1975		1974	1975	1974	1975	1974	1975
Spring Burn									
Green-tailed Towhee	11.7	22.2	27.0	625.3	1198.0	232.6	446.2		
Vesper Sparrow	3.9	11.6	22.0	169.8	509.5	67.2	201.5		
White-crowned Sparrow	3.9	5.8	28.5	220.0	330.0	80.5	120.8		
Blue Grouse	11.7	11.7	1027.5	23796.9	23796.9	2971.6	2971.5		
TOTALS	30.9	51.2		24812.1	25834.5	3351.9	3740.0	0.14	0.15
Fall Burn									
Green-tailed Towhee	34.7	0.0	27.0	1873.3	0.0	696.9	0.0		
Vesper Sparrow	11.3	0.0	22.0	495.0	0.0	195.8	0.0		
White-crowned Sparrow	16.9	0.0	28.5	962.2	0.0	352.2	0.0		
Blue Grouse	11.3	0.0	1027.5	23118.8	0.0	2886.9	0.0		
Western Meadowlark	3.8	0.0	104.8	786.0	0.0	194.7	0.0		
TOTALS	77.8	0.0		27235.2	0.0	4326.5	0.0	0.16	0.0
Unburned-control									
Green-tailed Towhee	32.4	30.4	27.0	1749.6	1640.5	650.9	610.6		
Vesper Sparrow	10.1	12.2	22.0	445.7	534.6	176.3	211.5		
White-crowned Sparrow	20.3	22.3	28.5	1154.3	1270.0	422.5	464.9		
Blue Grouse	8.1	16.2	1027.5	16645.5	33291.0	2078.6	4157.1		
Western Meadowlark	4.1	0.0	104.8	848.9	0.0	210.3	0.0		
Chipping Sparrow	4.1	0.0	12.2	98.8	0.0	46.6	0.0		
TOTALS	79.0	81.0		20942.8	36736.1	3585.6	5444.1	0.17	0.15

Appendix D. Analysis of non-breeding avifauna on Burro Hill spring burn study area. 1974-1975

Species	Density (Indiv./40.5 ha)		Mean wt./ bird(g)	Standing Crop Biomass (g/40.5 ha)		Consuming Biomass (g/40.5 ha)		Efficiency Index	
	1974	1975		1974	1975	1974	1975	1974	1975
Red-shafted Flicker	9.7	4.8	145.0	1399.3	700.4	314.4	157.4		
Red-tailed Hawk	0.6	0.3	1078.5	625.5	334.3	77.0	41.2		
Sparrow Hawk	4.8	1.0	111.0	536.1	107.7	130.5	26.2		
Sandhill Crane	1.9	2.5	4195.8	8097.9	10876.1	663.0	889.8		
Tree Swallow	14.5	10.3	20.0	289.6	206.2	117.9	83.9		
Barn Swallow	5.3	9.3	17.0	90.6	158.8	38.7	67.9		
American Robin	8.2	2.2	88.0	723.4	197.1	188.8	51.5		
Mountain Bluebird	8.2	6.8	26.6	218.7	179.8	81.7	67.2		
Audubon's Warbler	4.4	4.2	13.0	56.7	54.2	26.3	25.1		
Brewer's Blackbird	4.8	3.9	53.0	256.0	204.6	77.8	62.2		
Oregon Junco	4.8	1.6	17.7	85.5	28.7	36.1	12.1		
Western Tanager	0.6	1.6	29.0	18.6	47.0	6.8	17.1		
TOTALS	67.9	48.6		12397.7	13085.8	1759.0	1501.4	0.14	0.12

Appendix E. Analysis of non-breeding avifauna on Burro Hill fall burn study area. 1974-1975.

Species	Density (Indiv./40.5 ha)		Mean wt./ bird(g)	Standing Crop Biomass (g/40.5 ha)		Consuming Biomass (g/40.5 ha)		Efficiency Index	
	1974	1975		1974	1975	1974	1975	1974	1975
Red-shafted Flicker	0.9	7.2	145.0	136.3	1044.0	30.6	234.6		
Red-tailed Hawk	0.5	3.5	1078.5	528.5	3720.8	65.0	457.9		
Marsh Hawk	0.0	1.6	464.0	0.0	733.9	0.0	116.3		
Swainson's Hawk	0.0	1.9	988.5	0.0	1858.4	0.0	234.8		
Sparrow Hawk	0.5	3.5	111.0	54.4	383.0	13.2	93.2		
Sandhill Crane	0.0	5.6	4195.8	0.0	23622.4	0.0	1934.1		
Tree Swallow	6.1	13.4	20.0	122.2	268.6	49.8	109.3		
Barn Swallow	3.3	10.3	17.0	56.1	175.3	24.0	74.9		
American Robin	1.9	5.9	88.0	165.4	521.8	43.2	136.2		
Mountain Bluebird	2.8	17.2	26.6	74.8	457.0	27.9	170.8		
Audubon's Warbler	0.9	15.3	13.0	12.2	198.9	5.7	92.1		
Brewer's Blackbird	0.0	5.0	53.0	0.0	264.5	0.0	80.4		
Oregon Junco	1.4	6.3	17.7	25.3	110.8	10.7	46.8		
Hairy Woodpecker	0.0	1.9	69.8	0.0	131.2	0.0	36.8		
White-crowned Sparrow	0.0	17.8	28.5	0.0	507.6	0.0	185.8		
Blue Grouse	0.0	6.9	1027.5	0.0	7048.7	0.0	880.2		
Clark's Nutcracker	0.0	0.6	130.0	0.0	83.2	0.0	19.3		
Western Tanager	0.0	0.3	29.0	0.0	8.7	0.0	3.2		
Pine Siskin	0.9	1.2	12.1	11.4	15.0	5.4	7.1		
Green-tailed Towhee	0.0	8.4	27.0	0.0	227.9	0.0	84.8		
Vesper Sparrow	0.0	6.6	22.0	0.0	114.2	0.0	57.1		
TOTALS	19.3	140.3		1186.6	41495.7	275.5	5055.6	0.23	0.12

Appendix F. Analysis of non-breeding avifauna on Burro Hill unburned-control study area. 1974-1975.

Species	Density (Indiv./40.5 ha)		Mean wt./ bird(g)	Standing Crop Biomass (g/40.5 ha)		Consuming Biomass (g/40.5 ha)		Efficiency Index	
	1974	1975		1974	1975	1974	1975	1974	1975
Red-shafted Flicker	2.0	3.0	145.0	294.4	440.8	61.1	99.0		
Red-tailed Hawk	0.5	0.3	1078.5	139.4	85.0	70.4	42.5		
Sparrow Hawk	2.6	0.3	111.0	283.0	35.5	68.9	8.7		
Tree Swallow	11.7	4.6	20.0	233.2	91.6	94.9	37.3		
Barn Swallow	4.6	3.0	17.0	77.9	51.7	33.3	22.1		
American Robin	1.5	2.0	88.0	135.5	178.6	35.4	46.6		
Mountain Bluebird	3.0	2.0	26.6	80.9	54.0	30.2	20.2		
Brewer's Blackbird	9.1	5.4	53.0	482.8	285.7	146.7	86.8		
Oregon Junco	3.0	3.0	17.7	53.8	53.8	22.7	22.7		
Audubon's Warbler	1.0	0.3	13.0	13.1	4.2	6.1	1.9		
TOTALS	39.1	24.1		1794.0	1280.8	574.7	387.8	0.32	0.30

Appendix G. Analysis of total avifauna on Burro Hill study areas. 1974-1975.

Study Area	Density (Indiv./40.5 ha)		Standing Crop Biomass (g/40.5 ha)		Consuming Biomass (g/40.5 ha)		Efficiency Index	
	1974	1975	1974	1975	1974	1975	1974	1975
Spring Burn	129.7	150.9	37209.8	38920.2	5110.9	5241.9	0.14	0.13
Fall Burn	175.0	140.4	28421.7	41495.7	4602.0	5055.6	0.16	0.12
Unburned-control	197.0	186.1	22736.8	38016.9	4159.9	5832.0	0.18	0.15